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ABSTRACT

The initial steps necessary for constructing an analogies test are described. Basic mathematics being the context, the aim of the test is to predict student performance in research statistics courses characteristic of graduate education and social science programs. Items involving analogies in a quantitative context were built, sorted into two forms of the test (Q-Analogies), administered to beginning statistics classes, and analyzed on the BICAL program. Two revised forms of the Q-Analogies Test were developed and administered to intermediate classes. A basic algebra test was also administered to the classes. Results suggest the following for the Q-Analogies: (1) it is superior to an algebra test in predicting success in quantitative courses; (2) it measures with high reliability; (3) scores on both forms are quite comparable and simply equated; (4) it discriminates between groups defined on the basis of mathematical expertise; and (5) it appears promising as a valid, reliable measure of quantitative ability and warrants further trial. (Author/GK)

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Q-Analogies: a test of quantitative reasoning

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The Miller's Analogies Test has for years held an honored position among admissions tests, because it combines the assessment of a wide range of academic knowledge with the reasoning processes required by the analogies format. The MAT, however, is a verbal test almost exclusively, and is limited in that regard. For the assessment of quantitative reasoning, a second similar test would need to be developed. Therefore, it seemed useful to develop a test similar to the MAT that would focus on quantitative ideas.

Analogies have long been seen as a test of reasoning ability (Spearman and Jones 1950, Vernon 1960). Analogies typically load on the first factor (g) in a set of mental ability tests, whereas tests of mechanics of quantitative topics are likely to load on more specific factors (Vernon 1960). Analogy items require some knowledge of the subject within which the analogy is to be made. Indeed, the test is intended to assess a combination of knowledge and reasoning ability in the context of that knowledge.

An analogy item asks the examinee to discover a relationship between two stimuli, and then generalize that relationship to two other stimuli which may or may not be imbedded in the

same topical context. For example, 9 is to 3 as X^2 is to _____. Here one compares 9 to 3, may conclude that the latter is the square root of the former, generalize this conclusion to the more abstract symbol X. Some knowledge of arithmetic and the use of symbols in mathematics is needed to solve this problem, but this knowledge alone will not produce the answer. The reasoning aspect of the analogy is also required.

It may also be argued that basic mathematical knowledge and reasoning are processes that go into success in quantitative courses in the social sciences. For example, in a course in statistical methods, the student must not only know fundamental mathematics, but also be able to do effective reasoning within the context of quantitative topics.

It therefore seemed appropriate that a test composed of analogies, in which the context was basic mathematics, would be useful in predicting how well students would perform in the research statistics courses that characterize graduate programs in education and other social sciences. The purpose of this paper was to describe the initial steps in building such a test.

Procedure

Since the above rationale appeared productive, the next step was to build appropriate items. Some 80 items were initially constructed for try-out. This pool of items was set into the format used by the well-known Miller's Analogies Test, and all items carefully edited. On the basis of experimenter

judgment, items were sorted into two forms of the test (J-1, C-2) with ten items common to both tests. The tests were dubbed "Q-Analogies."

The initial analysis was done to assess basic item quality. The tests were administered to four beginning statistics classes. A test analysis followed, using a Rasch procedure as applied in the BICAL program. Items were scrutinized, based on goodness of fit and on difficulty. Items that deviated widely on fit were carefully examined, revised or eliminated. Items were also viewed to see how well a range of difficulty was covered, and whether all alternatives for each item were attracting responses.

Based on the ten items common to both tests, equivalence of scores between J-1 and C-2 was assessed. The tests were found to provide scores equivalent within less than 2 points.

The test was revised on the basis of the above cited scrutiny. Some items were also moved from one form of the test to the other to better spread items across the difficulty range. The revised tests (forms C-4 and J-3) were printed, with 45 items in each form, ten of which were common to both forms. Form C-4 was administered to one large beginning statistics class and two intermediate classes. These data were used to test the hypothesis below.

In addition, a basic algebra test was administered, involving simple linear equations, basic arithmetic rules, and factoring. The entire beginning class, but only one section of the intermediate classes, took this test.

If the Q-Analogies test is a valid measure of quantitative reasoning it should correlate positively, but at best moderately, with total performance in beginning statistics. This course centers on basic descriptive procedures and involves only modest amounts of reasoning ability. The test should also correlate with total performance in intermediate statistics, but since this course involves experimental design, requiring somewhat more problem solving, choice of methodologies, testing of assumptions, it was believed that more reasoning is required for success than in the introductory course. For this reason the Q-Analogies should correlate higher with the intermediate course than the introductory course.

Further, since a test of basic algebra emphasizes the mechanics of mathematics more than reasoning, scores on a test of basic algebra should correlate less well with course performance in intermediate statistics than will the scores on the Q-Analogies, but probably should correlate fairly well with performance in the beginning course. In addition, since algebra and Q-Analogies both deal with mathematics, some overlap is to be expected, but since the Q-Analogies contains the additional reasoning element, where algebra contains less of this, correlations between the two tests should be moderate, at best.

A further test of the validity of the Q-Analogies is in its ability to discriminate among defined groups who appear to have clear differences in ability to reason mathematically. The test, if it is measuring an ability on which these groups

differ, will produce higher scores for groups hypothesized to have more mathematical ability.

The following hypotheses therefore seemed reasonable:

1. Q-Analogies will correlate with total course test scores in the intermediate statistics course at least at a moderate level,

2. because the mathematics component will be more important than the reasoning component, the Q-Analogies will correlate with total course test scores in beginning statistics at a lower level than in intermediate statistics,

3. Q-Analogies and the algebra tests will correlate about equally with scores in the beginning course, but Q-Analogies will correlate more highly with intermediate course performance than does the algebra test,

4. Q-Analogies will correlate only moderately with the albegra test, and

5. The scores on the Q-Analogies should be highest for a group of mathematics teaching assistants, next highest for the intermediate statistics students, and lowest for the beginning statistics group.

Results

The correlations among the three variables - Q-Analogies, albegra, total course test scores - were calculated for the intermediate statistics data, and again for the beginning class data. The results are provided in Table 1 for the beginning class and in Table 2 for the intermediate class.

Table 1

Correlations and descriptive data
for beginning statistics students

Variable	Q-AN.	STAT.
ALG	.630 (N=39)	.570 (N=36)
Q-AN		.395 (N=38)

Variable	$\bar{X}$	σ	N
ALG	39.81	9.13	39
Q-AN	21.21	5.34	42
STAT	117.58	16.39	38

The data in Table 1 show that the Q-Analogies correlates modestly with course performance (.40). It also correlates moderately (.63) with the algebra test. The algebra test also correlates moderately (.57) with the course performance.

Table 2

Correlations and descriptive data
for intermediate statistics students

Variable	Q-AN.	STAT.
ALG	.545 (N=27)	.171 (N=27)
Q-AN		.418 (N=61)

Variable	$\bar{X}$	σ	N
ALG	41.30	10.21	27
Q-AN	25.21	8.05	66
STAT	113.56	17.37	61

In table 2 the data show some differences compared with Table 1. The algebra test does not correlate as well with course performance in the intermediate course. Also, the

Q-Analogies correlates slightly higher with course performance, but certainly not significantly so.

The data in Table 1 and 2 appear to support hypothesis 1; the Q-Analogies test does correlate substantially with intermediate statistics course performance. They do not support hypothesis 2; the Q-Analogies correlates about equally well with course performance at both levels. The third hypothesis is partly supported; Q-Analogies correlates higher with intermediate course performance than does the algebra test, but the algebra test correlated slightly higher with course performance than did the Q-Analogies at the beginning level. The next hypothesis is also supported; the Q-Analogies and algebra tests correlate only moderately.

One further bit of information was collected in regard to Q-Analogies' validity. A group of fifteen mathematics teaching assistants also took the test. Their scores were compared with scores of beginning, and with intermediate statistics students in a one way analysis of variance, with Dunn's test between groups. Presumably, the teaching assistants should score higher on Q-Analogies than is true of the statistics students, but the intermediate students should score higher than the beginning class because of the modest selection factor involved. The overall F test was 23.24. The Dunn's test produced a .05 critical value of 4.43 between mathematics TAs and intermediate students, 3.00 between intermediate and beginning students. In both comparisons the mean difference exceeded the critical value. It should be pointed out at this juncture that the scores on the three groups were not adjusted for general mental ability.

Several additional steps have also been taken in this analysis. Form C-4 was equated with form J-3 by administering J-3 to two additional sections of beginning statistics and one section of beginning calculus. Since the two forms had ten items in common, they could be equated by Rasch procedures. The equating showed that C-4 plus 1.6 equalled J-3. In other words, C-4 is just slightly harder than J-3, but with a small adjustment the scores are equal.

In another analysis of the data partial correlations were calculated to show the correlation between Q-Analogies and statistics performance with algebra held constant. In the introductory course the correlation was .05, while in the intermediate course it was .38. These figures lend further credence to the hypothesis that the algebra component of the introductory course is central, whereas the reasoning component in the intermediate course is somewhat more evident.

Some of our colleagues have also asked what the reliability of the test has been shown to be, disregarding our fit statistics produced for the Rasch analysis. Therefore, a conventional Kuder-Richardson formula 20 analysis was done. The resulting coefficient was .94 for C-4, .92 for J-3.

Conclusions

The data suggest the following conclusions:

1. the Q-Analogies predict success in quantitative courses moderately well.

2. the Q-Analogies is superior to an algebra test in predicting success in quantitative courses, presumably because of the reasoning component in Q-Analogies,
3. Q-Analogies measures with high reliability in both forms,
4. scores are quite comparable on the two forms and can be simply equated,
5. the Q-Analogies tentatively discriminates between groups defined on the basis of mathematical expertise, and
6. overall, the Q-Analogies appears to have promise as a valid and reliable measure of ability to deal with quantitative concepts, and hence warrants further trial.

REFERENCES

Spearman, C.; Jones L.L., Human Abilities, London: Macmillan, 1950.

Vernon, P.E., Intelligence and Attainment Tests, New York: Philosophical Library, 1960.